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Thiamethoxam in Tropical Agroecosystems

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Abstract

Because of its effectiveness in combating pests in agricultural crops, the group of neonicotinoids has regained importance, within this group the insectice thiamethoxan is highlighted. It was registered in México in 2004, from then until now its use has not been restricted. In order to establish the current situation of the use of thiamethoxam in México and other countries, a documentary study has been made, so this allows us to know both the damages and benefits caused to the ecosystem. It has now been found that the massive use of this insecticide causes harm to public health and also represents a danger to animals and plants coexisting in agrocultural ecosystems. One of the thiamethoxam's characteristics, which allowed its use, is their efficiency in the fight against sucking insects such as, the whitefly (*Bemisia tabaci*), aphids and mites. Applying it, over both the floor and the canopy of the plant, has become a threat to bees, since they are natural pollinators of 90% of tropical fruit and vegetables. It is considered to cause damage to soil organisms and because its high mobility allows it to be present in surface water, causing death among aquatic species. This analysis proposes using sustainable techniques and methodologies to ensure minimal environmental impact; one of them would be applying an organic or sustainable agriculture to guarantee the welfare and health of social groups.

Keywords: neonicotinoids, ecosystems, systems,

Introduction

Agriculture worldwide has evolved since the beginning of processes for the agronomic management to the marketing of fresh produce; this, in order to meet the demand for food in the world. In this context the use of agrochemicals, which began in the Second World War and ended in the late twentieth century, became known as the green revolution, also called among other terms, industrial agriculture and commercial agriculture. The introduction of chemicals of agricultural uses such as pesticides revolutionized agriculture, making these compounds became indispensable to produce crops. Mainly in areas in which, without the use of those pesticides, it would not be possible to achieve and extend the period of plant development, and thereby increase their yield and production; as well as maintaining its quality and increasing its storage period. Currently, hundreds of pesticides of different chemical nature are used in agriculture; this with the purpose of removing weeds and fungi pests from crops. Its application has also non-agricultural purposes, such as controlling weeds in the roads and industrial areas. This situation led to the indiscriminate use of pesticides and thus a negative impact to soil, water, aquatic environments and genetic erosion level in addition to damage to public health (Castañeda *et al.*, 2011). This period, in which an uncontrolled use of pesticide was used, is justified with the ideology of increasing food production to combat the specter of famine. This strengthened the chemical combat, this method was identified to control pests and diseases, but without measuring damage to the environment and public health. (Moreno and López, 2005; Plengue *et al.*, 2007; De la Isla, 2013).

Currently the study of agroecosystems as a model representing the effects of various systems, such as subsistence, transition, and business production, coupled to systems of consciousness and conceptual theoretical approach (Casanova *et al.*, 2015). It allows those involved in this model, understanding the extent of damage to natural ecosystems as a result of anthropogenic activities carried out in the different agricultural areas. It also shows the impact that pesticides, which are used to control pests and diseases in different crops, are causing. These pesticides are classified by their mode of action (Table 1) and by its chemical structure.

Table 1. Classification of pesticides currently used in agriculture, according to their mode of action (Bedmar, 2011).

Chemical Group	**Growth Regulators**	**Food Toxins**	**Respiratory System**	**Physical Toxics**
Organochlorine	Benzoyl-phenylurea	Bacillus thuringiensis	Phosphides	Minerales Oils
Organophosphorus	Benzamides		Bromides	Diatomaceous Earth
Carbamates	Benzoyl-hydrazines			
Pyrethroids				Silica Gels
Phenylpyrazole Fiproles				
Avermectin				
Neonicotinoid-nitromethylene				
Nicotine				

The chemical group of neonicotinoids is a group of systemic insecticides of low acute toxicity, which is efficiently used in pest control of economically important crops, including Aphidae (aphid), Aleyrodidae (whiteflies), Cicadellidae (leafhoppers), Chrysomelidae (among others rootworm western corn), Elateridae (wireworms), Fulgoroidea (planthoppers), Pseudococcidae (mealybugs), and Phytophagous mites (Elbert *et al*., 2008; Jeschke *et al.,* 2011). Some of these groups can also transmit viruses, so that neonicotinoids can also help control insect vectors of viral diseases of crops. However, its broad spectrum leads to undesirable effects on non-target insects (Maini *et al.,* 2010; Lanzoni *et al.,* 2012).

Thiamethoxam is found in this group of neonicotinoids, being a second generation insecticide that can be applied to crops through irrigation water, mainly in vegetables and fruit such as papaya Carica (De Souza *et al.,* 2006). Other uses of neonicotinoids in agriculture are in controlling insects and pests, seed treatment, control of infectious vectors in pets, livestock, urban and household pests and preserving wood. Its use is affecting the organisms that inhabit this ecological niche, with impacts that cause the death of honeybees and aquatic species. Similarly cause water, soil and air pollution (Van der Sluisjs *et al.,* 2015). Studies have established that only 0.1% of the amount of pesticides used in the agricultural ecosystem fulfills its function, while the rest circulate in the environment (Torres and Capote, 2004). The insecticide thiamethoxam, is used for effective control of the pest known as whitefly (*Bemisia sp*.) Its sale is free, and not restricted in México. Its use is massive, and when referring to control pests in fruit and vegetable it becomes of high importance. In México, in the state of Mexicali, it is reported that 800 tons of pesticides were used to control *Bemisia argentifolli*, during the cycle of cotton, wheat, and corn. This activity spanned an area of approximately 300,000 hectares, which caused serious problems to public health, due to the presence of these pesticides in soil and water (Valdez *et al.,* 2000).

Continuing reports of non-governmental and academic organizations on the chronic effects on public health and the devastating consequences on ecosystems because of the use and management of organochlorine and organophosphorus pesticides commonly applied; accelerated their replacement by the use of other chemicals with different action mode as neonicotinoids (Moreno and López, 2005). The purpose of this review is to determine the use and management of thiamethoxam in agroecosystems and the risks to public health.

Pesticides and Public Health

In this situation the prospect of agrochemicals in agriculture changed in the demonstration and presence of the first cases of human disease caused by the excessive use of pesticides. The World Health Organization (WHO) estimates that each year between 500,000 and 1,000,000 people have been poisoned by pesticides and from those 5,000 to 20,000 have died (Valdés *et al.,* 2000, Plengue *et al*., 2007). Exposure to these pesticides cause diseases such as Parkinson (PD) in humans, which are caused by drugs that increase the availability of acetylcholine at synapses via inhibition of acetylcholinesterase. Among the pesticides that are acetylcholinesterase inhibitors (Ahne), 55% of them belong to the group of organophosphates, 11% to carbamates and the rest to others, these have been detected in environmental samples and food (Castillo, *et al.,* 2007). Neonicotinoids act directly on nicotinic receptors of the acetylcholine and can cause cancer in humans, but lacking specific studies on the damage to public health (Van der Sluijs *et al.,* 2015). The indiscriminate use of pesticides and their inhibitory effect on the enzyme cholinesterase has initiated a reduction in the levels of this enzyme in blood, causing a number of effects on the body, such as genetic malformations in newborns and leukemia (Parra and De la Fuentes, 1995[a]; Parra and De la

Fuentes, 1995[b]; Zamora *et al.*, 2009). In Cuba during the period of 1994 and 1997, poisonings at home were recorded in 1125 children between 10 and 15 years old. Among those 21.9% are accidental poisonings due to storing pesticide containers, and six of these cases were fatal (Oduardo *et al.*, 1999). These cases are some of the consequences because of the lack of knowledge of users in handling pesticides. For example, in México, in the state of Veracruz, the group of organochlorine was found, between 9 and 20 ppm of DDT (dichloro-diphenyl tricloetano) in young people under 20 years old, and in Thailand in 1995, it was found in the blood of pregnant women, with values ranging from: 10.15, 6.95, 3.56, 1.47, 1.21, 1.61, 1.03, 0.80 ppb (Waliszewski *et al.*, 1996; Atisook *et al.*, 1997.). The group of organochlorine generates effects on the endocrine system which can be mutagenic, carcinogenic, that can affect the nervous system and accumulate in the fatty system (Dua *et al.*, 1996). In the sixties in Baja California, México, 559 people suffered poisoning by eating bread made with contaminated flour parathion, which belongs to the group of organophosphates; 16 of these cases, mostly children, died. There were also reported 50 cases of leukemia and allergic reactions (Valdez *et al.*, 2000). In the case of pyrethroids, which alter the immune and nervous system, causing skin disorders such as allergic reactions and dermatitis (Plengue *et al.*, 2007). The neonicotinoids group consists of imidacloprid, acetamiprid, tiaclorprid, clotiamidina and thiamethoxam. People who are poisoned by these suffer fatigue, pain, muscle weakness, and respiratory muscle involvement. Chronic toxicity consists of thyroid alterations, hypercholesterolemia and weakly mutagenic (Avivar *et al.*, 2007).

Management and Use of Thiamethoxam in Tropical Agroecosystems

A tropical agroecosystem is known as the unit of study where phenomena and human activities occur altering the elements that interact with each other in the system. This allows dramatic changes affecting the operation thereof, such as chemical, biological and physical contamination (Lango *et al.*, 2012; Megchún *et al.*, 2015), chemical pollution in agroecosystems is by massive use of pesticides that harm organisms residing in soil, water and environment. This has allowed the use of new permitted and efficient pesticides in controlling insects and pest. The group of neonicotinoids was recorded in the 1990s in Japan and Europe. The thiamethoxam was recorded in 2002 in México and Brazil (Milhome *et al.*, 2009); its molecular formula is $C_8\ H_{10}ClN_5\ O_3\ S$, solubility in water is 4.1 g L^{-1} (20 °C), has a vapor pressure of 6.60x 10^{-6} mPa, and the particle octanol-water (logP) is equal to -0.13. This is considered a second-generation neonicotinoid pesticide (Weber *et al.*, 2009).

Table 2. Properties and Characteristics of the thiamethoxam

Properties	Characteristics
Chemical Group	Neonicotinoids
Mode of Action	Sistemic and contact It is absorbed by the roots, traslocated through the vascular system and distributed in the foliage of the entire plant.
Degradation in soil DT_{50} (days)	50
Sediments in water DT_{50} (days)	40
Mobility	Mobile
Mammals: Acute oral LD_{50} (mg kg^{-1})	Higher 1563
Birds/birds: Acute LD_{50} (mg kg^{-1})	576
Honeybees: Acute contact 48 hours LD_{50} (µg bee^{-1})	0.024 (High)
Worms-Acute 14 days CL_{50} (mg kg^{-1})	Higher 1000
Arthropods: RL_{50} g ha^{-1}	100 % (Mortality, dose 0.02 kg ha^{-1})

Sánchez *et al*., 2012; Olivera *et al.*, 2013; University of Herfordshire, 2015.

Thiamethoxam, being a contact and systemic pesticide is used to control many pests as the leafminer (*Leucoptera coffella*), grubs (*Phyllophaga* spp), mealybugs (*Dysmicoccus brevipes*), nymphs of cicadas (*Quesada gigas*), and in the cultivation of coffee (*Coffea arabica* L.). Since it is efficient and has low acute toxicity is applied to foliage or irrigation systems in doses of 500 g ha^{-1} (De Souza *et al.*, 2006). In the case of tobacco, the ability to develop resistance to organochlorine insecticides, organophosphorus, carbamates and pyrethroids, pests such as aphids (*Myzus persicae nicotianae*) allowed the use of pesticides of a different mode of action such as thiamethoxam. Which blocks the nerve synapse by binding to the cholinergic receptor of the acetylcholine, and has the ability to act on contact or ingestion, when being incorporated from the substrate by the roots and be transported through the xylem to the tissues attacked by pests. The dose to control *Myzus persicae* is 1.75 kg ha^{-1} with a 50 days residual effect after application (Fuentes *et al.*, 2007). The whitefly (*Bemisia tabaci*), is a pest that attacks many

crops by transmitting 41 types of geminivirus by sucking and secreting sap from the crops, this leads to the development of fungi.

Out of all the pesticides authorized in México to combat *Bemisia tabaci*, only the insecticides neonicotinoid imidacloprid and thiamethoxam provide effective control. The thiamethoxam was recorded in 2004 and is applied once to the neck of the plant and four times to the foliage. In the cultivation of pepper (*Capsicum annuum* L.) the dose is 300 to 400 g ha^{-1} of the product. For tomato (*Solanum lycopersicum*) a dose of 600 g ha^{-1} of product is used (Gutiérrez *et al.,* 2007). Its use worldwide has increased to combat sucking insects such as aphids, whiteflies and triózidos (Campuzano *et al.,* 2010). In the case of citrus using a dose of thiamethoxam 25% (0.25 g. a. i.) applied to the soil and the trunk is efficient to control Australian red cochineal (*Aonidella aurantii* Maskell) in plantations of 3 to 4 years old. It has also proven effective for controlling leafminer, the Asian citrus psyllid (*Diaphorina citri*) and other psyllids and leafhoppers (Salas *et al.,* 2010; Villanueva *et al.,* 2011). In the case of sugarcane, one of the pests of economic importance is the cigarrilla (*Mahanarva fimbriolata*); applicating thiamethoxam is the efficient control. In Brazil it was found that there was an increased growth and also root development in sugarcane when applying thiamethoxam at a dose of 250 g ha^{-1}. While it may be that the effect of increase in the sugar cane development is influenced by macro and micronutrients applied (*Pereira et al.,* 2010). In rice cultivation, seeds are treated with thiamethoxam with a dose of 280 mL of product per 100 kg of seeds, which accelerates the process of germination and growth (Almeida *et al.,* 2012).

In the case of sugar cane and rice, seedlings and seeds, which are treated with thiamethoxam showed improvement in the absorption of nutrients and the development of natural endogenous hormones, expressing in better growth. No emergency or stress was presented, not manifest of the presence of pests in the soil (Jordan Casaretto, 2006, Rodríguez *et al.,* 2013). In growing papaya (*Carica papaya* L.) in India, when applying thiamethoxam, in doses of 5 ml/L for the control of arinosa chichen (Paracoccus marginatus), the populations of this pest were reduced by 78.7% (Gowda *et al.,* 2013).

Pollution of the aquifer by the use of thiamethoxam is due to its characteristic mobility with respect to soil type. In leptosols and vertisols soils it is highly leached and percolate, the mobility of this particle also depends largely on the amount of organic matter in soils. In leptosol soils in Brazil, in the period from November 2002 to April 2004, it was found thiamethoxam at a concentration of 0.5 mg L^{-1}, in percolated water to a depth of 0.90 to 1.80 meters (Amaral *et al.,* 2008). According to the criteria of the EPA (Environmental Protection Agency US) the thiamethoxam is considered as a pesticide of high potential to contaminate groundwater and surface water, this causes low water availability (Milhome *et al.,* 2009). However, in Spain thiamethoxam was used at 10% achieving an efficient control of Alphitobius diaperinus in poultry farming (Rodríguez *et al.,* 2013).

In México, an agroecosystem growing papaya (*Carica papaya* L.) in the municipality of Cotaxtla, Veracruz, represents 18% of the total area of the state, being the most important municipality and with the highest production in the country. Research centers in their technological packages recommend the use of thiamethoxam within authorized pesticides to control aphids, whiteflies and mites (*Sánchez et al.,* 2012). Agrochemicals distribution centers give technical advice on the use and management of thiamethoxam to eradicate sucking insects on crops of papaya and other vegetables; this phenomenon causes contamination of water and soil as identified and explained in the conceptual cyber model (Figure 1). However, the greater importance of using thiamethoxam is because in US, the EPA (2012) regulates the use of thiamethoxam in growing papaya with a tolerance level of 0.4 mg/l and, in the European Union the EFSA (European authority for Food Safety, 2012) allows a tolerance level of 0.05 mg/l. EFSA in the European Union asses the risk of damage to ecosystems by pesticides such as thiamethoxam. In México the CICOPLAFEST (Interministerial Commission for the Control Process and Use of Pesticides, Fertilizers and Toxic Substances) has not established tolerance limits for this product (*Sánchez et al.,* 2012). In the United States and the European Union the use of thiamethoxam and insecticides belonging to the group of neonicotinoids have caused deaths in honeybees (*Apis mellifera*), which are responsible for pollinating 90% of tropical fruit (Pereira, 2005; Olivera *et al.,* 2013); this phenomenon is called "collapse of the beehives," because bees die in concentrations of thiamethoxam from 1 to 100 ppb, damage to aquatic species can also occur if there are concentrations of <10 ppb and damage to macrofauna and microflora of the soil at 10 ppb by the presence of thiamethoxam, where the persistence in soil can last 3 years (Van der Sluisis *et al.,* 2015). This is an indication that damage to the macrofauna and microflora by the presence of thiamethoxam, generate infertile soils, soil loss and increased pollution of groundwater (Rebolledo *et al.,* 2011).

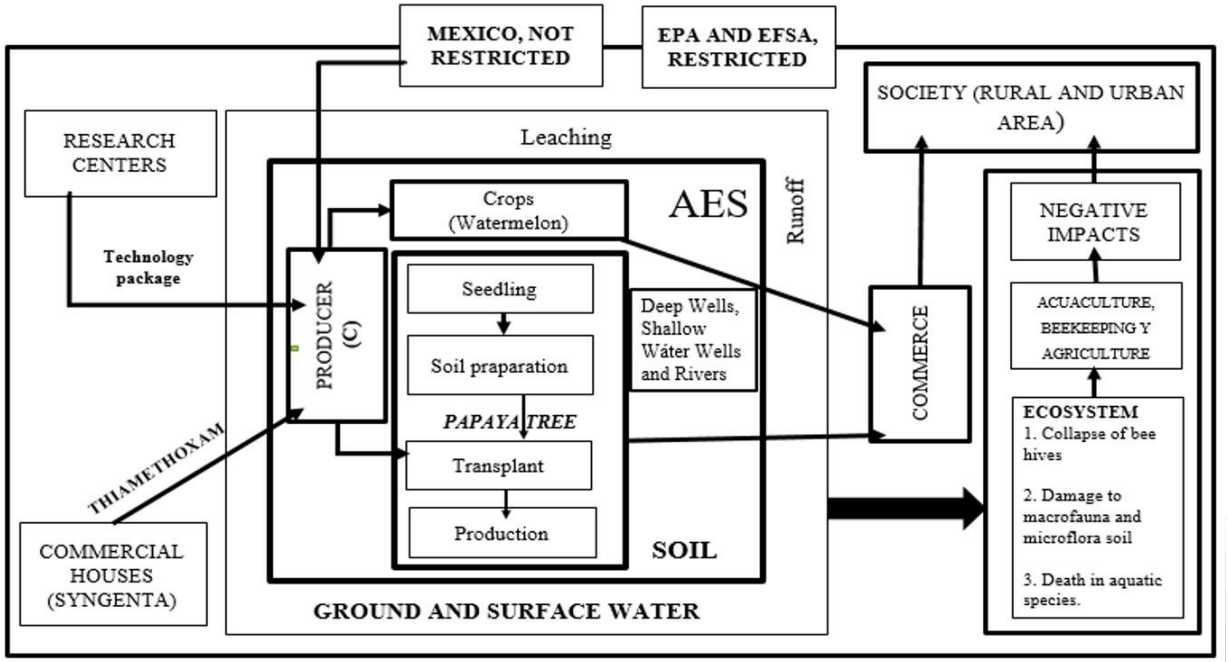

Figure 1. Cybernetic conceptual model of the presence of thiamethoxam in a Papaya agroecosystem (AES)

Improper use of pesticides increases the costs of production and pest resistance. When selecting a pesticide the active ingredient and an appropriate rotation of chemicals performance should be considered (Rodríguez *et al.*, 2013). One of the great challenges of agriculture is to seek a more sustainable way of producing, seeking sustainability of ecosystems. Make proposals that achieve to mitigate the damage caused by conventional agriculture, through programs of environment rescue. There are techniques and methods that besides integrating agriculture and ecology also seek a change of conception of subordinates and of society itself.

Organic or ecological farming is a form of production that manifests in essence a sustainable development using techniques that positively impact production processes and in doing so, are in harmony with nature and forms of organization of social life (Pérez, 2006). Examples would be the use of economic resources for the promotion of organic farming, establish a system of preferential loans through the Development Banking, programs of organic products for pest control, and a Trust for organic agriculture (Pérez, 2006). Organic management, through the production of chemical contaminants-free foods, can be an alternative to the imbalance of the environment (Valero, 2007; Megchún *et al.*, 2015). As is the case of using botanical biopesticides for controlling crop pests, these are composed of terpenes, alkaloids and phenolic compounds, cyanogenic glicísodos, sulfur compounds, and flavanoids besides having the advantage of being biodegradable and do not pollute natural resources such as water and soil (Nava, 2012), on the other hand, using control methods of vectors of viral diseases such as hedgerows, can be an alternative to use as trap crops in economically important crops (Hernández *et al.*, 2010).

Conclusion

The chemical group of neonicotinoids generates damage to ecosystems, such as the chemical group of organochlorines, organophosphates and pyrethroids that pollute soil, water and environment, due to poor agricultural management of crops in tropical agro-ecosystems. The use of thiamethoxam can cause direct impact ecological damage when causing the death of bees, aquatic organisms and soil degradation. In México the use and handling of this insecticide is not restricted. An alternative as a strategy to avoid damage to the agricultural ecosystem is to use sustainable technologies that improve production conditions. It is important to think about the new trends that agriculture requires, achieving awareness among producers and act against the overuse of chemicals that negatively impact ecosystems and consequently public health. Sharpen support through training programs, especially in rural areas, where people have little access to specialized medical care and the pace of life is highly vulnerable to disease. A controlled management of the insecticide thiamethoxam is essential to avoid the direct consequences on agricultural crops, which in turn have an impact on the quality of life of the inhabitants of these areas and food security.

References

1. Almeida A. da S., Villela F. A., Meneghello G. E., Lauxen L. R., Deuner C., 2012. Desempenho fisológico de sementes de aveia-preta tratadas con tiametoxam. Ciencias Agrarias, Londrina. Vol 33 (5): 1619-1628.
2. Amaral C. N. R., Oliveira R. R. L., De Lima J. M., Cesar G. M., 2008. Lixiviacao de inseticida thiamethoxam em macrolisimetros de duas clases de solo. Ciencia Agrotécnica Lavras. Vol 32 (6): 1818-1823.

3. Atisook R., Kham N; Toongsuwan, S. y Punnakanta L. 1997. Organochlorine compounds in perinatal blood samples maternal and neonatal measurements at Sirijat Hospital. Bangkok. Tailand. Sirijat. Hospital Gazette. 47(8): 712-717.
4. Avivar O. C., Camino D. F., Delgado R. M., Gómez P. C., Guillén E. J., Hernández J. A., Laynez B. F., Marín M. P., Parrón C. T., Pla M. A., Serrano R. J. L., Yélamos R. F., 2007. Respuesta ante las intoxicaciones agudas por plaguicidas: manual para el sanitario, vigilancia epidemiológica. 1ª ed., 2ª reimprenta (Sevilla). Consejería de salud. 105 p.
5. Bedmar, F. 2011. ¿Qué son los plaguicidas? Informe especial sobre plaguicidas agrícolas. 21 (122): 10-15.
6. Campuzano M. A., Rodríguez M. C., Lagunes T. A., Llanderal C. C., Terán V. A. P., Vera G. J., Vaquera H. H., Silva A. G., 2010. Aptitud biológica de poblaciones de *Bemisia tabaci* (Gennadius) Biotipo B (Hemiptera: Aleyrodidae) con diferente susceptibilidad al insecticida thiamethoxam. Neotropical Entomology 39 (3): 430-435.
7. Casanova P. L., Martínez D. J. P., López O. S., Landeros S. C., López R. G., Peña O. B., 2015. El agroecosistema comprendido desde la teoría de sistemas sociales autopoiéticos. Revista Mexicana de Ciencias Agrícolas 6(4): 855-865.
8. Castañeda, C. M. R., Lango, R. F., & Landeros, S. C. 2011. DDT in *Crassostrea virginica* (Gmelin, 1791) of coastal lagoons in the Gulf of Mexico. Journal of Agricultural Science, 3(1), 183-193.
9. Castillo, A. E., Subovsky, M. J., Sosa, L. A. A., Nunes, G. S. 2007. Persistencia del carbofuran en un molisol son diferentes usos. Revista UDO Agricola. 7(1): 204-208.
10. Castillo, A. E., Subovsky, M. J., Sosa, L. A. A., Nunes, G. S. 2007. Persistencia del carbofuran en un molisol son diferentes usos. Revista UDO Agricola. 7(1): 204-208.
11. De la Isla, B. Ma. de L. 2013. Historia de la Sociedad Mexicana de Agricultura Sostenible, A. C. (SOMAS). Edición: Colegio de Postgraduados. J. A. Villanueva J., C. Valdés L. 95 p. ISBN 1SBN 978-607-715-180-7.
12. De Souza, J. C., Rebelles R. P., De Oliveira R. R. L., Ciociola J. A. I., 2006. Eficiencia de thiamethoxam no controle do Bicho-Mineiro do cafeeiro. I-Influencia da modalidade de aplicacao. Coffe Science, Lavras. Vol. 1(2): 143-149.
13. Dua, V. K., Pant, C. S. y Sharma, V. P. 1996. Determination of level of HCH and DDT in soil, water, and whole blood from bioenvironmental and insecticide sprayed areas of malaria control. *Indian Journal of Malariology.* 33:1 7-15 India.
14. Elbert A., Haas M. Springer B., Thielert W. and Nauen R., 2008. Applied aspets of neonicotinoid uses in crop protection. Pest Management Science. 64: 1099-1105. Doi: 10.1002/ps.1616.
15. Fuentes C. E., Basoalto E., Sandoval C., Pavez P., Leal C., Burgos R. y Muños C., 2007. Evaluación de la eficiencia, efecto residual y de volteo de aplicaciones en pretrasplante de insecticidas neonicotinoides y mezclas de neonicotinoides-piretroides para el control de *Myzus persicae* nicotianae (Hemiptera: Aphididae) en Tabaco. Agricultura técnica (Chile). 67(1): 16-22.
16. Gowda G. B., Kumar L. V., Jagadish K. S., Kandakoor S. B., y Rani A. T., 2013. Efficacy of insecticides against papaya mealybug, Paracoccus marginatus Williams and granara de willink (Hemiptera: *pseudococcidae*). Current Biotica. 7 (3): 161-173.
17. Gutiérrez O. M., Rodríguez M. C., Llanderal C. C., Terán V. A. P., Lagunes T. A., Díaz G. O., 2007. Estabilidad de la resistencia a neonicotinoides en *Bemisia tabaci* (GENNADIUS), biotipo B de San Luis Potosí, México. Agrociencia. Vol 41 (8): 913-920.
18. Hernández, C. E., Villanueva J. A., Mora A. J. A., Nava D. C., 2010. Barrera de maíz en una estrategia de manejo integral para controlar epidemias del virus mancha anular del papayo (PRSV-P). Agrociencia: vol 4(3): 339-349
19. Jeschke P., Nauen R., Schindler M. and Elbert A., 2011. Overview of the status and global strategy for neonicotinoids. Journal of Agricultural and Food Chemistry. 59: 2807-2908. Dx/doi.org/10.1021//jf101303.
20. Jordán M. y Casaretto, 2006. Hormonas y reguladores del crecimiento: Fisiología vegetal (F.A. Squeo y L. Cardemil). Ediciones Universidades de la Serena, La Serena, Chile. V 150806: 28 p.
21. Lango R. F. Castañeda C. Ma. del R., Landeros S. C., Galaviz V. I., Navarrete R. G., Soto E. A., 2013. Cd, Cu, HG and Pb, Organochlorines pesticides in Commercially Important Benthic Organisms Coastal Lagoons SW Gulf of México. Agricultural Science Vol 1(1): 63-79.
22. Lanzoni A., Ade G., M. R., Radeghieri P., Pezzi F., 2014. Technological aspects of steinernema carpocapsae spray application alone or mixed with bacillus thuringensis aizawai in spinach crop. Bulletin of insectology. 67 (1): 115-123
23. Maini S., Medrzycki P., Porrini C., 2010. The puzzle of honeybee losses: a brief review. Bulletin of insectology. 63 (1): 153-160. Doi:10.1111/j.1462-2920.2009.02123
24. Megchun G. J. V., Landeros S. C., Soto E. A., Castañeda C. Ma. del R., Martínez D. J. P., Nikolskii G. I., Galaviz V. I., Lango R. F., 2015. Total coliforms and *Escherichia coli* in surface and subsurface wáter from sugarcane agroecosystem Veracruz, México. Journal of Agricultura Science. Vol 7(6): 110-119. Doi: 10.5539/jas.v7n6p110
25. Milhome M. A. L., De Sousa D. De O., Lima F. de A. F., Do Nascimento R. F., 2009. Avaliacao do potencial de contaminacao de águas superficiais e subterráneas por pesticidas aplicados na agricultura do Baixo Jaguaribe, CE. Eng. Sanit Ambient. Vol 14 (3): 363-372.
26. Moreno, M. J.A., Lopéz L. M. G. 2005. Desarrollo agrícola y uso de los agroquímicos en el valle de Méxicali. Estudios Fronterizos, Revista de ciencias sociales y humanidades. Vol. 6. No. 012. pp. 119-153.
27. Nava P. E., García G. C., Camacho B. J. R., Vaquez M. E. L., 2012. Bioplaguicidas: Una opción para el control biológico de plagas. Ra Ximhai. Vol 8 (3): 17-99.
28. Oduardo l. M; Martínez C. J. y Ramírez M. S.1999. Eventos tóxicos en la infancia según consultas telefónicas atendidas en el centro nacional de toxicología (1994-1997). *Rev Cubana Pediatr* [online]. vol.71 (2): 80-85.
29. Oliveira R. A., Cristina R. T., Malfitano C. S., 2013. Side effects of thiamethoxam on the brain and midgut of the Africanized honeybee Apis mellifera (hymenopptera: apidae). Environmental toxicology.1-12. Doi 10-1002/tox.
30. Parra, L. y De La Fuentes, C. 1995a. Contaminación por plaguicidas en sangre y leche materna de recien nacidos. Departamento de pediatría del hospital general de Calabozo. Mimeo. Guárico Venezuela.

31. Parra, L. y De La Fuentes, C. 1995b. Agrotoxicos, efectos en la población infantil de Calabozo. Departamento de pediatría del hospital general de Calabozo. Mimeo. Guárico. Venezuela.
32. Pereira J. M., Fernandez P. M., Veloso V. R. S., 2010. Efeito fisológico do insecticida thiamethoxam na cultura da cana-de-acucar. Arq. Instituto Biologico, Sao Paulo. Vol 77 (1): 159-164.
33. Pereira N. A. L. 2005. Abejas ancestrales, una mirada a la apicultura en Yucatán. Revista de la Universidad Autónoma de Yucatán. Num. 235: 86-91.
34. Pérez, C. J. 2006. La política del fomento a la agricultura orgánica. El cotidiano. Vol. 21. No. 139. pp. 101-106.
35. Plegue, T. F., Sierra, F.J. A., Castillo, S. Y. A. 2007. Riesgos a la salud humana causados por plaguicidas. Tecnociencia Chihuahua. Vol 1 (3). 1-6.
36. Rebolledo M. A., Del Ángel P. A., Megchún G. J. V., Adame G. J., Nataren V. J., y Capetillo B. A., 2011. Coberteras vivas para el manejo de malezas en mango (*Mangifera indica* L.) cv. Manila. Tropical and subtropical agroecosistems. 13: 327-338.
37. Rodríguez D., Xuárez M., Merino A., Larramendy R., Temprana M., Díaz O., Morales Y., Rebollar R., 2013. Evaluación en condiciones de laboratorio de la eficiencia de tres insecticidas de nuevo uso en la avicultura cubana para el control de *Alphitobius diaperinus*. Revista Salud Animal. Vol 35 (3): 197-200.
38. Salas H., Goane L., Casmuz A. S., Zapatiel S. A., Bernal M. y Lazcano J. M., 2010. Control químico de la cochinilla roja australiana (*Aonidiella aurantii* Maskell) con productos sistémicos aplicados al tronco y al suelo en plantaciones jóvenes de limonero. Revista Industrial y Agrícola de Tucumán. 87 (1): 39-44.
39. Sánchez B. M. A., Santamaria B. F., Zavala L. M. J., y López N. M. C., 2012. Plaguicidas organosintéticos autorizados en México y el mercado internacional para su uso en papaya. Instituto Nacional de Investigación Forestales, Agrícolas y Pecuarias. Campo Experimental Mocochá. Centro de investigación Regional Sureste. Mérida, Yucatán, México. 36 p.
40. Torres, D., Capote, T. 2004. Agroquímicos un problema ambiental global: uso del análisis químico como herramienta para el monitoreo ambiental. Asociación Española de Ecología Terrestre. Ecosistemas 13(3): 2-6.
41. University The Hertfordshire, 2015. PPDB: Pesticide Properties database. Disponilbe en: Http://sitem.Herts.Ac.Uk/aeru/footprint/es/reports/631.Htm.
42. Valdez, S. B., García, D. E. L., Cobo, R. J. M., López, B. G. 2000. Impacto de los plaguicidas en la salud de los habitantes del valle de Mexicali, México. Rev. Ecológica Latino Americana. Vol. &. No. 3. pp. 15-21.
43. Valero G., L. Agricultura orgánica: Generalidades en México. *In*: Memoria de la 2da Reunión Nacional de Innovación Agrícola y Forestal 2007. Guadalajara, México. 2007 Disponible en: http://www.rniaf.org.mx/ponencias/organica/p1_agricultura.pdf
44. Van der Sluijs, J.P., Amaral-Rogers, V., Belzunces, L.P., Bijleveld van Lexmond, M.F.I.J., Bonmatin, J-M., Chagnon, M., Downs, C.A., Furlan, L., Gibbons, D.W., Giorio, C., Girolami, V., Goulson, D., Kreutzweiser, D.P., Krupke, C., Liess, M., Long, E., McField, M., Mineau, P., Mitchell, E.A.D., Morrissey, C.A., Noome, D.A., Pisa, L., Settele, J., Simon-Delso, N., Stark, J.D., Tapparo, A., Van Dyck, H., van Praagh, J., Whitehorn, P.R., Wiemers, M. 2015. Conclusions of the worldwide-integrated assessment on the risks of neonicotinoids and fipronil to biodiversity and ecosystem functioning. Springer, Environmental Science and Pollution Research, 22: 148-154.
45. Villanueva J. J. A., Cabrera M. H., Aguilar R. L., José P. R., Canela C. J. J., Pérez A. A. W., 2011. Insecticidas para el control de Diaphorina citri kuwayana (Hemiptera: psyllidae) en toronja en la región central de Veracruz. 2 Simposio Nacional sobre investigación para el manejo del *Psílido asiático* de los cítricos y el Huanglongbing en México. 314-319.
46. Waliszewski, SM., Pardio, S., Chantiri, P. y Aguirre, G. 1996. Organochlorine pesticide body burnen of young Mexican. Fresenius enviromental Bulletin. 5: 5-6 357-360.
47. Weber O. L. dos S., Martins E. de L., Dores E. F. G. de C., Curado L. D. de A. 2009. Sorcao do insecticida tiametoxam nas fracoes orgánica e mineral de um latossolo amarelo. Química Nova. Vol 32 (9): 2259-2262.
48. Zamora, F. R., Torres, D., Rodríguez, N., Zamora, F. J. 2009. Impacto del uso de plaguicidas sobre los niveles de colinestaresa en sangre en productores agrícolas del asentamiento campesino Santa Teresa, Municipio Miranda del Estado Falcón, Venezuela. Revista Facultad de Agronomía. (UCV). 35(2): 56-61.